Space Weather Technical Forecast

Issued on Tuesday, 28 December 2021 at 12:58 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of G1/Minor Geomagnetic storms. Chance of R1 radio blackouts and Active electron fluence throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low to Moderate over the past 24 hours, with occasional C-class X-ray flares observed at GOES 16 in the period and an M-Class flare observed at 28/0405 UTC.
There are currently six active regions on the solar disc at present, including two as yet unnumbered in the northwestern quadrant. The disc was otherwise little changed on the preceding 24 hours, with 2919 remaining a unipolar Hrx/Alpha in the southeast, while earlier growth in 2920 in the southwest stalled, with the group retaining Cri/Beta complexity. The disc was otherwise dominated in terms of complexity and sunspot area by a pair of large sunspot regions: firstly AR2916 in the southeastern quadrant, which showed slight proliferation but retained a similar size and stature, with Ehi/Beta complexity. This left AR2918 in the northwest as Eai/Beta. No Coronal Mass Ejections (CMEs) were observed in available imagery during the period.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by DSCOVR at L1, was a slow-ambient at first becoming slightly elevated probably as a result of a connection to CH37/+, an extension of the northern crown. The solar wind density showed a general decrease, from an above average (around 30ppcc) to become Average by 27/1600 UTC. The IMF started at Moderate levels reaching 15nT around 27/400 UTC before moderating into the UTC evening, with the north-south component varying between +/-9nT. Finally, the phi angle was mostly positive (away from the sun).The net result of the above solar wind measures was provisionally mainly Quiet, but with a peak of Kp '4-' in the 12-15UTC interval, while the IMF and density were highest.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at Background levels. The high energy electron flux (greater than 2 MeV) started at High flux peaking at 3210pfu at both 27/1230 and 27/1325UTC, before falling to Normal Background with the onset of increased geomagnetic activity later in the UTC day. The fluence drifted lower through in the period with observed fluence at 28/0000UTC being 5.08e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate solar activity is forecast to continue throughout the period with further isolated M-class flares, most likely from AR2916 and AR2918. No significant regions are anticipated to emerge from the far-side onto the sun in the period.

Solar Wind / Geomagnetic Activity: The chances of G1 are given as 20% for the much of the period. The anticipated onset of CH39's high speed stream, perhaps most likely at the very end

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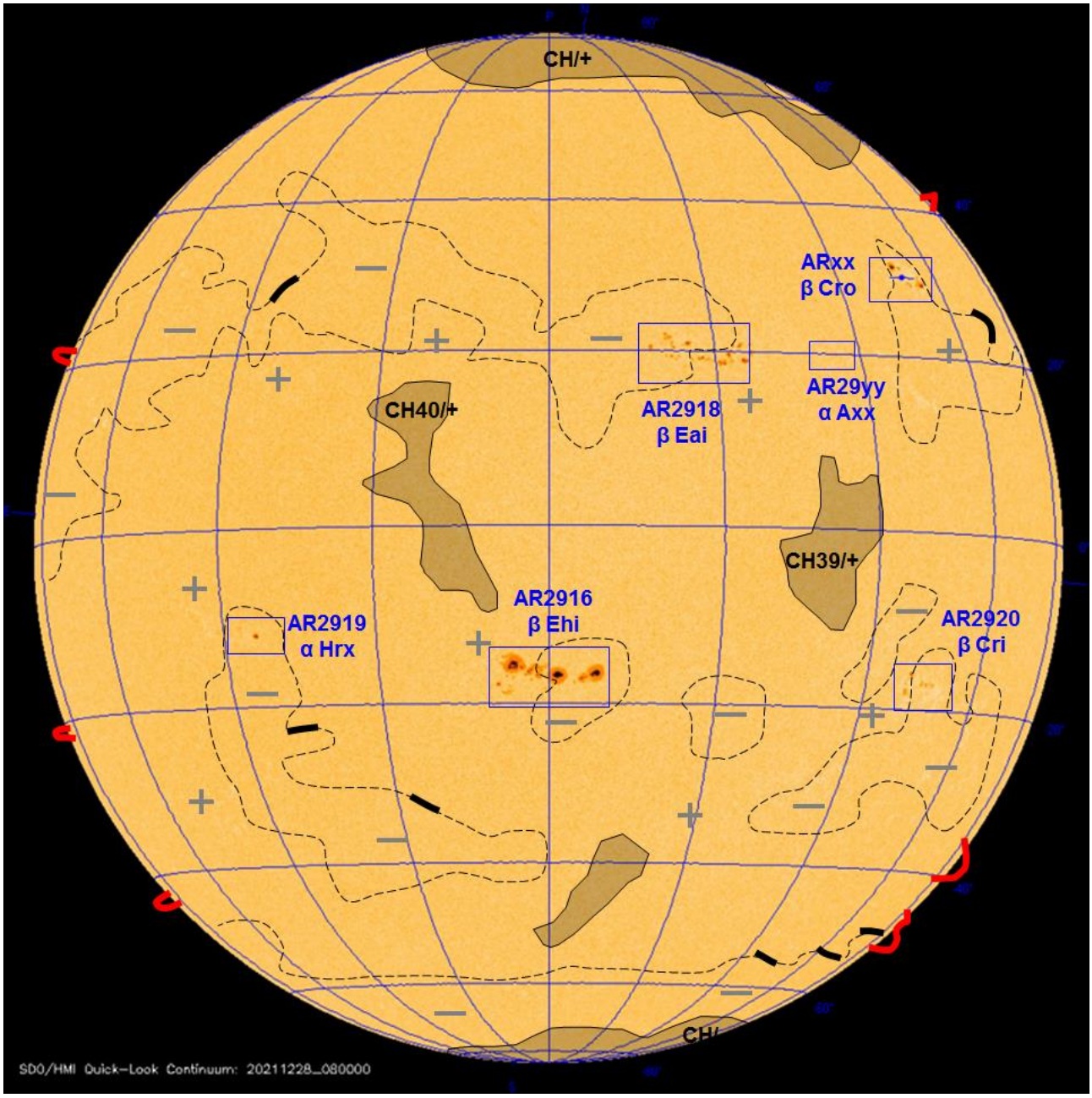
of day one or day two (Wednesday 29 December). The CME is likely to arrive on day three (Thursday 30 December), but may well give a glancing blow to Earth.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels, albeit with a daily Slight Chance of S1 should there be any significant flare activity. High energy electron flux (greater than 2MeV) levels are relatively uncertain, but will most likely track near the Active threshold with peaks in risk on days one and three, in antiphase with the most likely onset times of coronal holes.

Figure 1. Solar Analysis Valid 0800 UTC, 28 December 2021.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There is a small chance on day three, Thursday 30 December. of peripheral effects from a glancing blow from a filament eruption which occurred 26/2012UTC. This is currently forecast to most likely miss Earth, but again confidence is low given some MOSWOC Enlil ensemble members have glancing blows of Earth No other CMEs feature in the current forecast.
The coronal hole forecast for the same period is of low confidence due to lack of similarity of the current disc with last pass, but also the apparent dissimilarity of current conditions with those seen at STEREO A around 3 days upwind of Earth. Specifically, the current coronal hole enhancement, perhaps from CH37/+, is not especially obvious in MAG and PLASTIC data for the relevant period, with a more obvious spike due late day one or perhaps early day two (Wednesday 29 December), with this thought to emanate from CH39/+. This could provide the peak risk (20%) of geomagnetic storm intervals in the period, waning to end the working week but with a token uplift to 20% risk should CME effects materialise. The end of the month (around 31 December) is rounded out by a slightly more assured high speed stream from a persistent coronal hole, numbered CH40/+.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	20	10	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
27/0418 UTC	N/A	Filament eruption	SW quadrant	507km/s	Probable miss. Minority Enlil ensemble members suggest later on Thursday 30 Dec.	Small chance of glancing blow

Figure 2: Met Office ENLIL and ensemble product indicating CME from filament eruption arriving at Earth later on day three (30 December)

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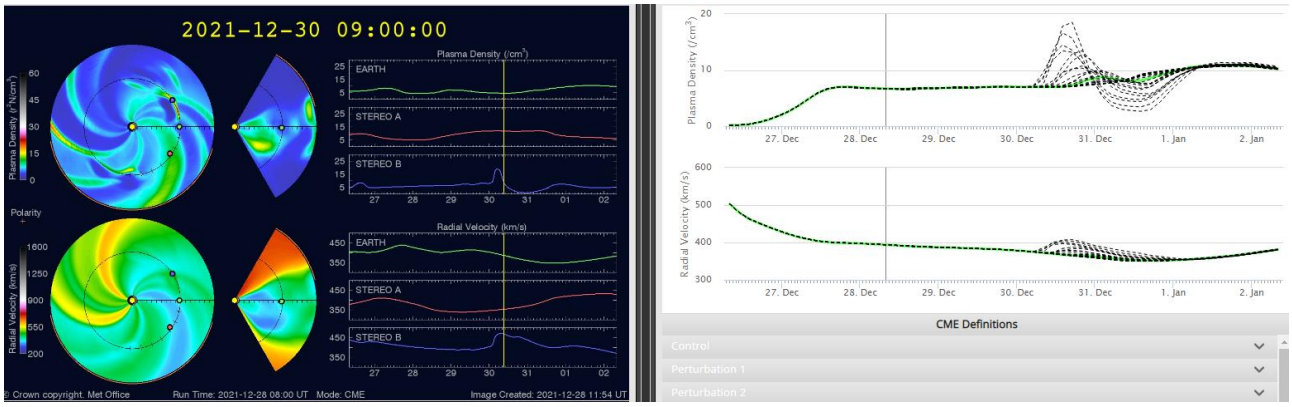


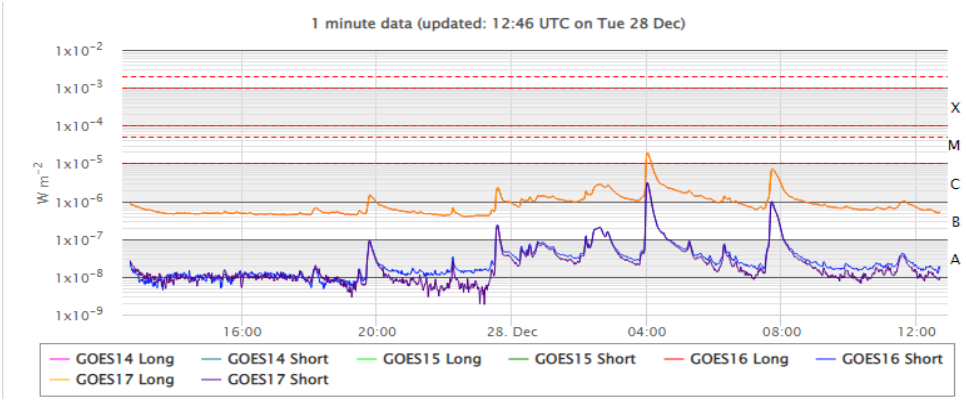
Radio Blackouts - X-Ray Flares:

Solar Activity has been Low to Moderate, with an M-class flare observed along with a number of small C-flares in the past 24 hours. Background X-ray flux recorded at GOES 16 continued to show an overall slight decline. The current Earth-facing disc is dominated by AR2916 and AR2918, although neither of these regions has delivered the full scope of their class, being Ehi/Beta and Eai/Beta respectively.

In terms of overall trends, no major returning regions are forecast over the eastern limb in the coming four-day period. This may give a relatively flat X-ray flare tendency. Solar activity is likely to continue Low, with further C-class flares. There is a daily Chance of activity increasing to Moderate levels, with isolated M-class flares. These are most likely to come from active regions 2916 and 2918.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	30	30	30	30
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: GOES 16 X-ray flux plot showing latest flares with M-Class flare around 28/0405 UTC.



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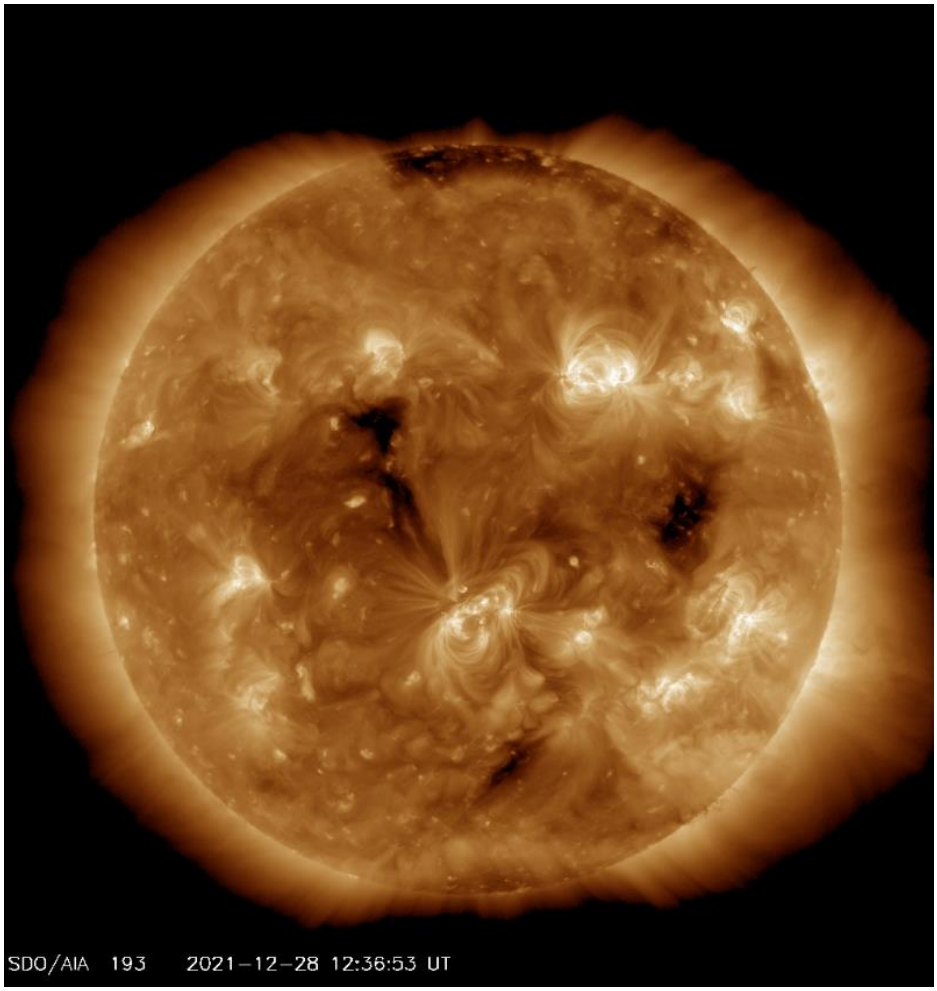
Solar Radiation Storms - (High Energy Protons):
The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently at Background levels and will most likely persist as such. There is a Slight Chance of S1 from any notable flares on the disc, perhaps most likely from AR2916 or AR2918 as they rotate further westwards across the western hemisphere.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Latest SDO aia 193 imagery showing location of coronal holes on visible disc.



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High Energy Electrons Event (≥ 2MeV):

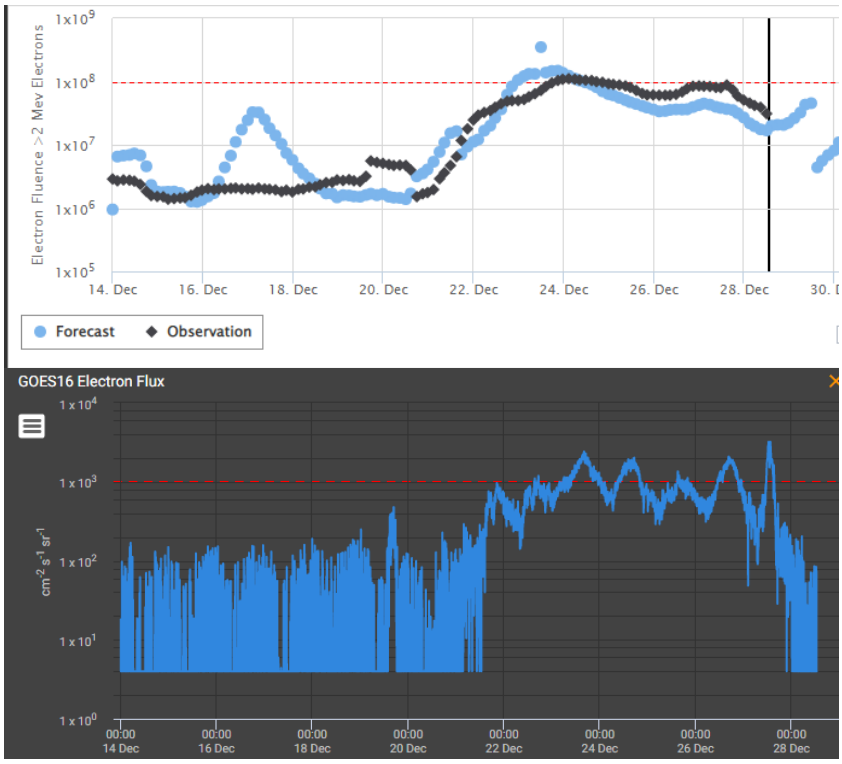
The diurnal oscillation in high energy (greater than 2MeV) electron flux, as observed by GOES-16 again showed an increase during the middle portion of the past UTC day, only to be attenuated by the arrival of a coronal hole high speed stream, perhaps from CH37/+. Because the solar wind environment Earth is encountering in this four-day period bears little resemblance to persistence, confidence is rather low for the period, with REFM's recent forecast trends markedly lower than observations and also proving volatile.

There is a Chance of Active fluence being realised once geomagnetic activity eases from the current high speed stream, probably only to be interrupted once again after midweek by a further high speed stream from CH39/+. The onset of CH40/+ is of higher confidence, for bearing greater similarity to its past incarnation. This may mean that arrival is most likely on day five, Saturday 1 January, again potentially denting electron fluence levels.

The forecast for fluence is therefore of low confidence throughout, but probably showing slightly higher chances of exceedance in the wake of the current coronal hole and CH39/+.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	20	30	40	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: High energy electron flux and Met Office REFM output over past two weeks, showing increase in activity during past week, which is now starting to wane.



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